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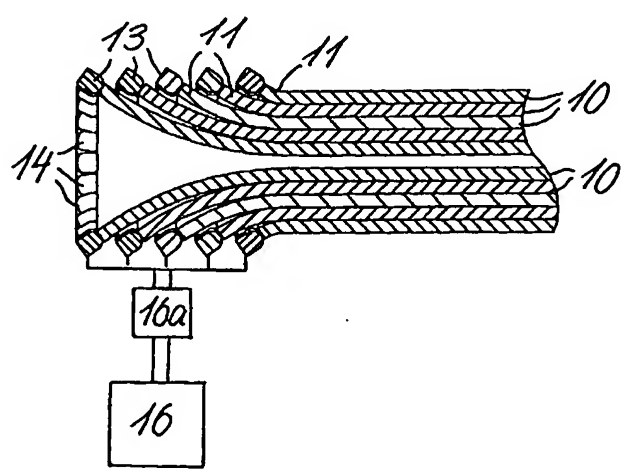
(54) Title: A LIGHT TRANSMITTING DEVICE AND METHODS FOR PRODUCING AND OPERATING THE SAME




(57) Abstract: A light-transmitting device comprises two or more tubular, elongated light guiding or transmitting members (10), which are arranged co-axially within each other. Each light guiding member has opposite light receiving and light emitting ends (11, 23). An annular light emitter assembly (13) with a plurality of light emitters (14) is positioned at the light receiving end (11) of each light guiding member (10) so as to emit light from the light emitters into the light receiving end of the respective light guiding member. The light receiving ends (11) of the guiding members are flared or trumpet shaped and mutually spaced axially so as to provide more space for the light emitter assemblies (13). The device may be used as a lamp or torch, for example for dental use, or for transmitting light signals. In the latter case the light emitting ends may be flared or widened like the light receiving ends so as to provide an enlarged contact surface, for example for transferring the light signals to an interface for converting the light into electrical signals.

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**A light transmitting device and methods for producing and operating the same**

Generally the present invention relates to a light transmitting device, which may, for example, be used for transmission of signals or data or as an illuminating device, such as a compact, high intensity light emitting device. e.g. for dental use.

Compact high intensity illuminating or lighting devices are desired in a number of situations – not only where little space is available, but also for simple convenience. High light intensities are obtainable by using LED's of different types, but a large number of such elements are required. Consequently, compacting these LED's at the same time as receiving the light emitted thereby and transporting this light to e.g. a small working area has been attempted in a number of applications. Solutions to this problem are disclosed in i.a. WO 99/16136 and WO 97/36552.

Even though these implementations solve the problem of transporting the light from the LED's to the working area, the production of such apparatus is difficult and labour-intensive.

The present invention provides a simpler implementation, which is more easily produced.

Thus, the present invention provides a light transmitting device comprising a plurality of substantially tubular, elongated light guiding or transmitting members arranged within each other, each light guiding member having opposite light receiving and light emitting ends, and a light emitter assembly including a plurality of light emitters being positioned at the light receiving end of each light guiding member so as to emit light from the light emitters into the light receiving end of the respective light guiding member.

The tubular light guiding means may, for example, be made separately and subsequently be inserted into each other, which means that the inner passage of a light guiding member should be dimensioned and shaped so as to be able to receive an adjacent inner light guiding member. Alternatively, two or more of the light guiding members may be produced by softening and drawing or stretching tubular blanks arranged within each other. In the latter case it is possible to produce light guiding means with cross-sectional dimensions varying along the length thereof, if desired. When used in the present specification and in

the present claims, the term "substantially tubular" should be interpreted to comprise also tubular members having one or more axially extending slits or slots.

The light-receiving end of each light guiding member preferably defines a substantially annular end surface, which may receive the light from the light emitters. Furthermore, the light emitters of each assembly are preferably positioned in an annular arrangement with a shape corresponding to the shape of the annular end surface of the light guiding member, whereby the total area of such an end surface may be utilised for transferring light into the respective guiding member. Furthermore, the light emitters are preferably positioned opposite to and adjacent to the annular end surface of the light guiding member. The light emitters in each assembly may all emit light of the same colour and the emitters in the various assemblies may be of different colours or wavelengths or the light emitters in one and the same assembly may emit light of different colours. The annular end surface may have any two-dimensional or three-dimensional shape. Preferably, however, the annular end surface has a substantially uniform width and is substantially at right angles to the adjacent peripheral surface parts.

The annular end surfaces of the various light guiding members are preferably mutually axially spaced in order to provide better room or space for the light emitters. The light guiding means, which are mutually nested or arranged within each other, may in principle be of different cross-sectional shapes and each light guiding member may have substantially the same cross-sectional shape along at least most of its length. For example, a light guiding member having a polygonal outer cross-sectional shape may be received in a cylindrical passage of an adjacent light guiding member, which means that the outer peripheral surface of a light guiding member does not necessarily have to be in abutting engagement with the adjacent inner peripheral surface of the adjacent surrounding light guiding member. However, said plurality of light guiding means are preferably substantially co-axially arranged, and in the preferred embodiment adjacent inner and outer surfaces of adjacent light guiding members are complementary and in mutual abutting engagement. In order to simplify production of the light-transmitting device, each of the tubular light guiding members preferably has a substantially circular, annular cross-sectional shape, so that the light guiding members may be simple cylindrical tubes.

In a preferred embodiment of the light-transmitting device according to invention the light-receiving end of each light guiding member is flaring or widening towards the free end

thereof. Thus, the light-receiving end of each light guiding member may have a trumpet-like shape. By this measure, the number of light emitters which may be associated with each light guiding member, and thereby the light intensity obtainable from each guiding member may be increased substantially.

The light emitters of said plurality of assemblies are preferably positioned along substantially identical cross-sectional curves, and the light receiving ends of the light guiding members may define substantially identical end surfaces forming curves corresponding to those of the assemblies. By providing light guiding means and light emitting assemblies defining the same cross sectional curves, only one type/size/dimension of assemblies is required. A curve is a well-defined spatial/metrical interconnected line in two-dimensional or three-dimensional space, such as a circle or a sine curve interposed on a circle. When all assemblies define at least substantially the same curve, only a single type of assembly is required - independently of the number of light emitters in the assembly and independently of the number of assemblies in the light-transmitting device. When identical or at least substantially identical curves or end surfaces are defined by the light receiving ends of the various light guiding members, the same geometrical and metrical relationship may be present between each light emitter and a corresponding part of the light receiving end of the light guiding member. As indicated above, the said curve or curves may be of any type, but is/are preferably a circle.

Preferably, light does not travel transversely from one light guide member into an adjacent guide member. The light intensity at the light-emitting end of the light-transmitting device may then be controlled over the light emitting end surfaces of the nested light guiding members. Depending i.a. on the wall thickness of the light guiding members, different intensities may be obtained. The light intensity obtained at the light emitting ends may be further controlled e.g. by changing the number of light emitters in each assembly and/or by changing the light emission thereof. As mentioned above, the annular end surfaces of the light receiving ends of the various light guiding members are preferably axially spaced, such that the light receiving ends of the light guiding members are not necessarily fully nested or enclosed in each other.

A preferred material for the light guiding members is quartz, and the guiding members may then be produced with or without flared or widened light receiving ends and a desired cross-section, such as a circular cross-section, in a drawing process. However, it should

be noted that virtually any curve or shape might be used - two-dimensional as well as three-dimensional. Depending on the wavelength of the light launched into the light guiding members, other materials than quartz may be used for the guiding members, such as glass, polymers or other plastic materials.

The light emitters may be virtually any type of light emitter. However, presently, semiconductor diodes are preferred, such as LED's of any type or laser diodes.

As mentioned above, the light receiving ends of the light guiding members may be flared or widened towards their free ends so that the annular end surfaces of the light receiving ends may be substantially identical or define substantially the same curves even though the light guiding members are arranged within each other or mutually nested. In such case, the said annular end surfaces may be positioned about substantially the same plane at right angles to the longitudinal axis of the light-transmitting device. Preferably, however, the various annular end surfaces and, consequently, the associated light emitter assemblies are positioned at different, mutually spaced positions along the longitudinal axis of the nested light guiding members.

In a preferred embodiment an outer peripheral surface part of the light receiving end of each light guiding member defines in an axial plane a first acute angle with a longitudinal axis of the light transmitting device, and said first acute angle is preferably at least substantially the same for all light guiding members. Normally, these outer peripheral surface parts are defined by the outermost parts of the light guiding member actually receiving the light and transporting it toward the main part of the light guiding member.

Also, the light emitters of each assembly are preferably adapted and positioned so as to emit light in a direction, which in an axial plane defines a second acute angle to the axis of the light-transmitting device. Preferably, a direction of highest intensity is directed at said second acute angle. Said first and second acute angles are preferably at least substantially identical in order to ensure optimum transfer of light into the light guiding members. The difference between the first and second angles may be at most ±10°, preferably at most ±5°, such as at most ±3°. This difference in angle will depend highly on e.g. the emitting characteristics of the light emitters as well as any distance between light emitting elements thereof and the light receiving ends of the light guiding members. The larger the

distance and the larger an angle of emission, the smaller the acceptable difference in angle.

Preferably the first and second acute angles are in the interval of 0-90°, such as 5-80°, preferably 15-60°, such as 20-50°, preferably 30-40°. This angle and the wall thickness of the individual light guiding member determine the amount of space available to the light emitters.

Preferably, the light emitters of each assembly are positioned along the annular end surface or curve with at least substantially even spacing. This ensures not only an even illumination of the annular light receiving end surfaces of light guiding members, but also an even distribution of heat generated by the light emitters.

A light emitter assembly may e.g. comprise 2-200 light emitters, such as 10-100 light emitters, such as 20-30 light emitters depending on e.g. the intensity desired. Also, at least one light emitter may comprise a light emitting diode or a diode laser, such as in the form of a SMD component or as a flip chip component. These very compact elements are especially advantageous when a large number of light emitters are to be used.

Especially when a large number of light emitters are used, heat generated by these emitters may cause a problem. Thus, at least one assembly may further comprise a heat-conducting element, the light emitters of the assembly being positioned with at least substantially the same distance to the heat-conducting element. Heat generated by the light emitters may then be transported to the heat-conducting element, whereby the heat is either dissipated or transferred to another element being able to dissipate the heat.

The specific type of light emitter and the attachment and electrical interconnection thereof may vary greatly. Thus, soldering may be used just as well as electrically conducting glues, and any type of light emitter may in principle be used.

The light-transmitting device according to the invention may further comprise means for operating the light emitters of the assemblies. Depending on the nature of the light emitters, the intensity of emitted light from the individual light emitter may simply be varied. In another embodiment, all light emitters of the light transmitting device are simply operated

– namely energized and de-energized – at the same time, for example when the light transmitting device is used as a torch or lamp.

However, it is normally preferred that the operating means are adapted to operate the light emitters of one assembly separately from the operation of another assembly or one type of light emitter separately from other types of light emitters. In this manner, different intensities may be provided, or different light emitters having different emission characteristics may be operated so that also different wavelengths or wavelength "mixes" may be emitted. Thus, it may be desired that the operating means are adapted to selectively operate individual light emitters or groups of light emitters of an assembly.

Furthermore, at least one of the assemblies may comprise at least two types of light emitters, so that for example one type of light emitter is adapted to emit light in a first wavelength range, while the other type of light emitter is adapted to emit light in a second, different wavelength range. This combined with the fact that the light from one light emitter assembly may be guided solely or at least substantially solely by the pertaining light guiding member provides a number of possibilities of light emission at the light emitting ends of the light guiding members. Thus, the various light emitter assemblies of a light transmitting device and the associated mutually nested light guiding members may emit different and/or varying light intensities and/or wavelengths/wavelength "mixes". Thus, a great variety of light signals may be generated, which is of great importance when the light-transmitting device according to the invention is used as a data-transmitting device. In the latter case the light-emitting end of each light guiding member is preferably flaring or widening towards the free end thereof so as to provide an increased contact surfaces at the signal output end of the transmitting device. Also, the light emitting end of the light transmitting device is preferably adapted to be connected to a signal conversion device or an interface for converting light signals into electrical signals. Thus, the light-conducting device according to the invention may be used for generating light signals and for transmitting the same over great distances.

As mentioned above, the device according to the invention may also be used as a torch, lamp or another illuminating device. In such case it may not be desired to have the above-mentioned variation over the area of the light emitting ends of the light guiding members. One way of obviating this problem is to either use light guiding members of a type in which the light is able to travel transversely from one light guiding member to another,

whereby the light from the individual assemblies will be sufficiently mixed after a certain length of travel. Another manner of mixing the light from various guiding members is to transfer the light into a single light guiding member, such as by emitting the light from the nested light guiding members into a single, common light guiding member, e.g. via a lens. Even when the light emitted into the common light guiding member is spatially structured like that of the nested light guiding members, this spatial structure will be lost along the length of the common light guiding member.

According to a further aspect, the present invention provides a method of producing a light transmitting device, said method comprising: providing a plurality of elongated, tubular light guiding members each having opposite light receiving and light emitting ends, the light receiving ends of the light guiding means defining at least substantially identical cross sectional curves, positioning the tubular light guiding members substantially concentrically within each other in a nested manner, providing one or more assemblies of light emitters and positioning the light emitters on each assembly along a curve corresponding to the cross-sectional shape of the inlet end of a corresponding light guiding member, and positioning each assembly in relation to the corresponding light guiding member so as to emit light into the light receiving end of the light guiding member. A substantially annular end surface may be defined on the light-receiving end of each light guiding member, and the light emitters of each assembly may be positioned in an annular arrangement with a shape corresponding to the shape of the annular end surface of the light guiding member.

The present invention further provides a method for operating the light transmitting device described above, said method comprising selectively energizing and de-energizing the light emitters of the various light emitter assemblies so as to provide light signals, and transmitting such signals from the light receiving to the light emitting ends of the light guiding members. Such light signals may, for example, be composed by pulsating light signal components provided by at least some of the light emitter assemblies and transmitting such signal components through the respective light guiding member. The light signals may, for example, be provided by varying frequency, light intensity, pulse width, pulse distance and/or light wavelength.

The light signals emitted from the light emitting ends of the light guiding members are preferably converted into electrical signals, whereafter they may be processed in known data processing devices.

In the following, the invention will be further described with reference to the drawings, wherein

Fig.1 is a side view of a first embodiment of the light-transmitting device according to the present invention,

Fig. 2 is a longitudinal sectional view of the device shown in Fig.1,

Fig. 3 is a perspective view of the device shown in Figs. 1 and 2,

Fig. 4 is a perspective view in an enlarged scale of an embodiment of an assembly of light emitters forming part of the device shown in Figs. 1-3,

Figs. 5 and 6 are a side view and a longitudinal sectional view, respectively, of one of the light guiding members of the device of Figs. 1-3, shown in a reduced scale,

Fig. 7 is a detailed view illustrating the mounting of an assembly of light emitters,

Fig. 8 is a perspective view further illustrating how an assembly of light emitters may be mounted on a light guiding member,

Fig. 9 is a perspective view of a second embodiment of the light-transmitting device according to the invention, part of a cover having been cut away,

Figs. 10 and 11 are a front view and a perspective view, respectively, of a third embodiment of the light-transmitting device according to the invention,

Fig. 12 is a side view of a fourth embodiment,

Figs. 13, 14, and 15 are a front view, a longitudinal sectional view, and a perspective view, respectively of the embodiment illustrated in Fig. 12,

Fig. 16 is a perspective view of a mounting device with an assembly of light emitters,

Figs. 17 and 18 are side views of a fifth and sixth embodiment of the device according to the invention,

Figs. 19 and 20 illustrate a manner of obtaining a substantially evenly distributed light output,

Figs 21, 22, and 23 are a perspective view, an end view, and a longitudinal sectional view, respectively, of a seventh embodiment of the light transmitting device according to the invention, and

Figs. 24 and 25 illustrate how light signals transmitted by means of a transmitting device of the type shown in Figs. 21-23 may be converted into electrical signals by means of a converting device,

In the drawing, various embodiments of the light-transmitting device according to the invention are shown. The light-transmitting device comprises two or more tubular, preferably cylindrical light guiding members 10 arranged within each other or in nested relationship. Any outer guiding member 10 preferably has an inner diameter slightly smaller than the outer diameter of an adjacent inner guide member. The guide members may have any desired longitudinal extension varying from a few centimetres to several kilometres. Each light guiding member 10 has a flared or trumpet-shaped light-receiving end 11 defining an annular end surface 12, which is preferably substantially at right angles to the adjacent peripheral side surface portions of the guiding member 10.

Even though the inner and outer diameters of the light guiding members 10 are different in order to allow these members to be received within each other, the annular end surfaces 12 are preferably similar or substantially identical, and they are preferably axially spaced as shown in the drawings. Also, the angle defined between the longitudinal axis and the inner and outer peripheral surfaces of the light receiving end 11 of the guiding member 10 is preferably substantially the same for all of the guiding member of the light transmitting device. An annular assembly 13 of light emitters 14, such as diodes, is positioned adjacent to the annular end surface 12 of each light guiding member 10 so as to emit light substantially at right angles to said end surface. Because the dimensions of the annular

end surfaces 12 are substantially the same for all of the light guiding members 10 of a light-transmitting device, identical or similar light emitter assemblies 13 may be used for all of the light guiding members 10.

The individual tubular light guiding members 10 may be made of different materials or materials having different reflective indices, or materials having different reflective indices may be positioned in spaces or interstices between individual tubes. The use of different materials with different reflective indices for adjacent guiding members 10 tends to prevent or counteract that light transmitted by one guiding member 10 is mixed with light transmitted by an adjacent guiding member.

In the embodiment shown in Figs. 1-3 the light-transmitting device comprises five light guiding members 10 having annular end surfaces 12 being similar regarding dimensions and arranged axially spaced. Each of these surfaces 12 is provided with an annular assembly 13 or arrangement of light emitters 14. The angle defined between the symmetry axis or main axis of light emission from each light emitter or light emitting diode (LED) and the longitudinal axis of the light transmitting device is 35°.

An assembly 13 may comprise any number of light emitters or light emitting elements 14 and may be assembled in any suitable manner. As an example, standard 3mm light emitting diodes (LED) may be used as illustrated in Fig. 4, but also SMD mounted elements or flip chip elements may be used as illustrated in Fig. 8. As shown in Fig. 7 an annular recess 15 may be formed in the free end of the light receiving or inlet end 11 of the guiding member 10 for receiving the light emitters 14.

The individual LED's 14 are interconnected and connected to a power supply 16 and a control device 16a, which are diagrammatically illustrated in Fig. 2, and which may, for example, be arranged in a housing or cover 17 (Fig. 9) forming part of the device. The light emitters are preferably mounted as a self-supporting mounting unit 18. Preferably this unit comprises a heat-conducting circular or semicircular (in case of a circular light receiving end) element along which the individual light emitting elements 14 are positioned with at least substantially even spacing. The actual mounting of the light emitters 14 on the circular or semicircular element may be performed in any suitable manner, such as by soldering or gluing (for example by means of electrically conducting glue).

In Figs. 5-8 a guiding member 10 and its pertaining assembly 13 are illustrated. As best seen in Figs. 7 and 8, the mounting unit with the light emitters is in the form of a pair of semi-circular elements 18 exemplified by using two annular elements 16 and 18, which are assembled to form a circular assembly, which is maintained in the desired position within the recess 15 by means of a pair of fastening rings 19 and 20.

Figs. 9 -11 show an embodiment similar to that shown in Figs. 1-5. However, the light receiving ends or inlet ends of the light guiding means 10 are surrounded by a housing or an outer protective cover 17. Depending on the other elements of the device such protective cover may render the device able to withstand autoclaving.

Figs. 10 and 11 illustrate a light guiding member 10 in which the light receiving end or inlet end 11 of the tubular member 10 has been provided with longitudinally extending slits or slots 21 so as to form longitudinally extending projections 22 each being adapted to receive light emitted from one of the light emitters 14 of the assembly 13. The function of the projections 22 is to direct the light from each of the emitters 14 in the longitudinal direction of the tubular member 10 toward the opposite light emitting end or outlet end 23 thereof. The shape and inclination of the light-receiving end 11 of the tubular member 10 should correspond to that of the assembly 13, and the number and position of the slits or slots 21 should correspond to the number and position of the individual light emitters 14 of the assembly 12. It is possible, however, to arrange more than one light emitter 14 so that they are associated with and emit light into a single projection 22.

Figs. 12-15 illustrate an embodiment of the light-transmitting device according to the invention which is rather similar to that of Figs. 1-9. The embodiment shown in Figs. 12-15 comprises only two tubular light guiding members 10 and two corresponding light emitter assemblies 13. These assemblies 13 do not comprise standard LED's, but SMD diodes 14 which are smaller, so that a large number of diodes may be positioned in an assembly having a given diameter. Also in this embodiment the diodes or light emitters 14 are preferably positioned at or on a circular heat-conducting member 18 with an even spacing in order to remove the heat generated by the diodes in order to avoid overheating of the diodes 14. The heat-conducting members 18 may themselves be able to dissipate this heat, or the heat may be further transported to other elements for dissipation.

The diode chips 14 may be bonded directly to the light guiding member 10. Thus, the diodes may, for example, be fastened by means of silicone, and electrical contacts to the diodes may be provided by arranging contacting pads in the silicone and electrical conductors though the silicone from the diodes to the contacting pads. In this manner the diodes 14 may be attached and a resilient contact may be provided. Contacting of this type is disclosed in WO 99/62146.

The contact pads may e.g. be positioned radially so that one pad of each diode may be contacted by an outer electrical conductor and another by an inner electrical conductor. Another manner of attaching the diodes 14 of this embodiment is to bind the diodes directly to a frame member in order to obtain self-containing assemblies.

Fig. 17 illustrates an embodiment similar to that of Figs. 1-6, in which half the light emitters 14 are of one colour and the other half of a different colour. These differently coloured light emitters 14 are arranged alternatingly along the annular end surface 12 of the tubular light guiding member 10. In this manner an even illumination of the light guiding members 10 may be obtained by any of the different colours, or by a mixture of the two colours.

Fig. 18 illustrates another manner of selectively providing and transmitting anyone of several different colours. In this embodiment, the three assemblies 13 each comprise a plurality of diodes 14 of a single colour, and the diodes on the three light guiding members 10 are different, for example red, blue, and yellow, respectively. In this manner, energizing the diodes 14 of one assembly 13 will provide light of the pertaining colour. When two or three of the assemblies 13 are energized, light with a mixture of the respective colours will be provided - one colour in each of the pertaining tubular light guiding members 10.

Figs. 19 and 20 illustrate how a uniform (regarding colour and/or intensity) light output may be obtained even when lights of different colours are transmitted through the light transmitting device, for example the device shown in Fig. 18, in which light of different wavelengths (or wavelength ranges) travels along different light guiding members 10. In Fig. 18 yellow light is transmitted only by the outermost light guiding member, blue light is transmitted only by the intermediate guiding member, and red light is transmitted only by the innermost guiding member 10. However, if the light from the light emitting ends 23 of the three nested tubular light guiding members 10 is sent into another unitary light guide

24, for example via a lens 25 as shown, a more uniform light beam is provided, when the has passed a suitable length of the light guide 24.

One example of a use of a device of the type described is dental use, for example for hardening plastics for dental fillings. At present, such plastic filling materials require blue light for hardening. However, as future filling materials may require different light with other wavelengths, or the device is to be used e.g. for illumination in the patient's mouth, multiple, selectable wavelengths may be desired.

Figs. 21-23 illustrate an embodiment of the light-transmitting device according to the invention, which may be used for the transmission of data in the form of light signals. Such signals may be in the form of light pulses of varying frequency, wavelength, and/or light intensity for any of the various tubular light guiding members 10. In the embodiment shown, the light emitting ends 23 of the members 10 are flared or widened toward their free ends in a similar manner as the flared light receiving ends 11, and connecting members 26 may be mounted at the free outlet ends or light emitting ends of each light guiding member 10.

Figs. 24 and 25 illustrate how a light-transmitting device as that shown in Fig. 23 may be used for transmitting electrical data signals. Such electrical signals from a signal source (not shown) are transmitted to an input interface 27 in which the electrical signals via the diodes of the assemblies 13 are converted into light signals. These light signals are then transmitted by the light-transmitting device to an output interface 28, which is connected to the connecting members 26 of the co-axial light guiding members 10. In the output interface 28, the light signals may be converted into electrical signals, which may then be further processed in a data processing device 29 shown in Fig. 25. The input and output interfaces 27 and 28 may be of the type disclosed in Danish patent application No. PA 2000 00641 filed 14 April 2000. Such interfaces comprise electrical circuits 30 formed on co-axial, radially spaced cylindrical surfaces. The diameters of such surfaces with the electrical circuits may correspond to the diameters of the free outlet ends 23 of the various light guiding members 10.

It should be understood that various changes and modifications of the embodiments described above and shown in the drawings could be made without departing from the scope of the present invention as defined in the claims.

CLAIMS

1. A light transmitting device comprising:

a plurality of substantially tubular, elongated light guiding or transmitting members arranged within each other, each light guiding member having opposite light receiving and light emitting ends, and

a light emitter assembly including a plurality of light emitters being positioned at the light receiving end of each light guiding member so as to emit light from the light emitters into the light receiving end of the respective light guiding member.

2. A device according to claim 1, wherein the light receiving end of each light guiding member defines a substantially annular end surface.

3. A device according to claim 2, wherein the light emitters of each assembly are positioned in an annular arrangement with a shape corresponding to the shape of the annular end surface of the light guiding member.

4. A device according to claim 2 or 3, wherein the light emitters are positioned opposite and adjacent to the annular end surface of the light guiding member.

5. A device according to any of the claims 1-5, wherein said plurality of light guiding means is substantially co-axial.

6. A device according to any of the claims 1-5, wherein adjacent inner and outer surfaces of adjacent light guiding members are complementary and in mutual abutting engagement

7. A device according to any of the claims 1-6, wherein each of the light guiding members has a substantially circular, annular cross-sectional shape.

8. A device according to any of the claims 1-7, wherein the light receiving end of each light guiding member is flaring or widening towards the free end thereof.

9. A device according to any of the claims 1-8, wherein the light emitters of said plurality of assemblies are positioned along substantially identical cross-sectional curves.

10. A device according to claim 9, wherein the light receiving ends of the light guiding members define substantially identical end surfaces forming curves corresponding to those of the assemblies.

11. A device according to any of the claims 8-10, wherein an outer peripheral surface of the light receiving end of each light guiding member defines in an axial plane a first acute angle with a longitudinal axis of the light transmitting device.

12. A device according to claim 11, wherein said first acute angle is at least substantially the same for all light guiding members.

13. A device according to any of the claims 1-12, wherein the light emitters of each assembly are adapted and positioned so as to emit light in a direction which in an axial plane defines a second acute angle to the axis of the light transmitting device.

14. A device according to claim 13, wherein said first and second acute angles are substantially identical so as to deviate at most ±10°, preferably at most ±5° and more preferred at most ±3°.

15. A device according to any of the claims 11-14, wherein said first and second acute angles are in the range of 5-80°, preferably 15-60°, such as 20-50°, and more preferred 30-40°.

16. A device according to any of claims 1-15, wherein the light emitters of each assembly are substantially mutually evenly spaced.

17. A device according to any of claims 1-16, wherein at least one of the assemblies comprises 2-200 light emitters, such as 10-100 light emitters, preferably 20-30 light emitters.

18. A device according to any of claims 1-17, wherein at least one of the light emitters comprises a light emitting diode or a diode laser, such as in the form of a SMD component or in the form of a flip chip component.

19. A device according to any of the claims 1-18, wherein at least one of the assemblies further comprises a heat conducting element, the light emitters of the assembly being positioned with at least substantially the same distance to the heat conducting element.

20. A device according to any of claims 1-19, further comprising means for operating the light emitters of the assemblies.

21. A device according to claim 20, wherein the operating means are adapted to operate the light emitters of one of said assemblies separately from the operation of any other of the assemblies.

22. A device according to claim 20 or 21, wherein the operating means are adapted to operate the light emitters of an assembly or groups of such light emitters individually.

23. A device according to any of claims 1-22, wherein at least one of the assemblies comprises at least two types of light emitters.

24. A device according to claim 23, wherein one of said at least two types of light emitters is adapted to emit light in a first wavelength range, and wherein another type of said light emitters is adapted to emit light in a second wavelength range being different from the first range.

25. A device according to any of the claims 1-24, wherein the light emitting end of each light guiding member is flaring or widening towards the free end thereof.

26. A device according to any of the claims 1-25, which is in the form of a lamp, a torch or another illuminating device.

27. A device according to any of the claims 1-25, which is in the form of a data-transmitting device.

28. A device according to claim 27, wherein the light emitting end is adapted to be connected to a signal conversion device for converting light signals into electrical signals.

29. A method of producing a light transmitting device, said method comprising:

providing a plurality of elongated, tubular light guiding members each having opposite light receiving and light emitting ends, the light receiving ends of the light guiding means defining at least substantially identical cross-sectional curves,

positioning the tubular light guiding members substantially concentrically within each other in a nested manner,

providing one or more assemblies of light emitters and positioning the light emitters on each assembly along a curve corresponding to the cross-sectional shape of the inlet end of a corresponding light guiding member, and

positioning each assembly in relation to the corresponding light guiding member so as to emit light into the light-receiving end of the light guiding member.

30. A method according to claim 29, wherein a substantially annular end surface is defined on the light receiving end of each light guiding member, the light emitters of each assembly being positioned in an annular arrangement with a shape corresponding to the shape of the annular end surface of the light guiding member.

31. A method according to claim 30, wherein the light emitters are positioned opposite and adjacent to the annular end surface of the light guiding member.

32. A method according to any of the claims 29-30, wherein the light receiving end of each light guiding member is formed so as to flare or widen towards the free end thereof.

33. A method of operating a data transmitting device according to claim 27, said method comprising selectively energizing and de-energizing the light emitters of the various light emitter assemblies so as to provide light signals, and transmitting such signals from the light receiving to the light emitting ends of the light guiding members.

34. A method according to claim 33, wherein said light signals are composed by pulsating light signal components provided by at least some of the light emitter assemblies and transmitting such signal components through the respective light guiding member.

35. A method according to claim 33 or 34, wherein the light signals are provided by varying frequency, light intensity, pulse width, pulse distance and/or light wavelength.

36. A method according to any of the claims 33-35, wherein light signals emitted from the light emitting ends of the light guiding members are converted into electrical signals.

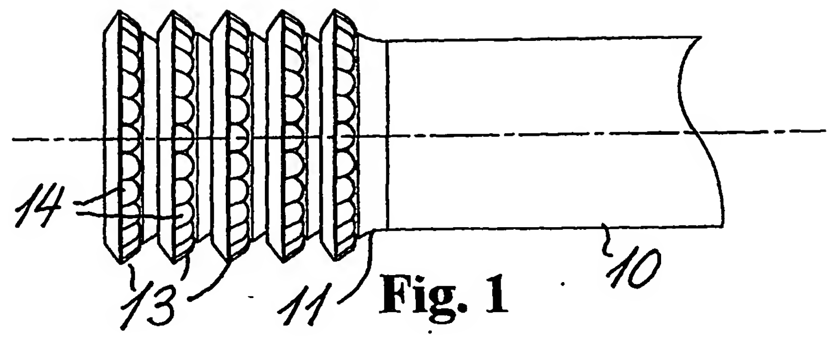


Fig. 1

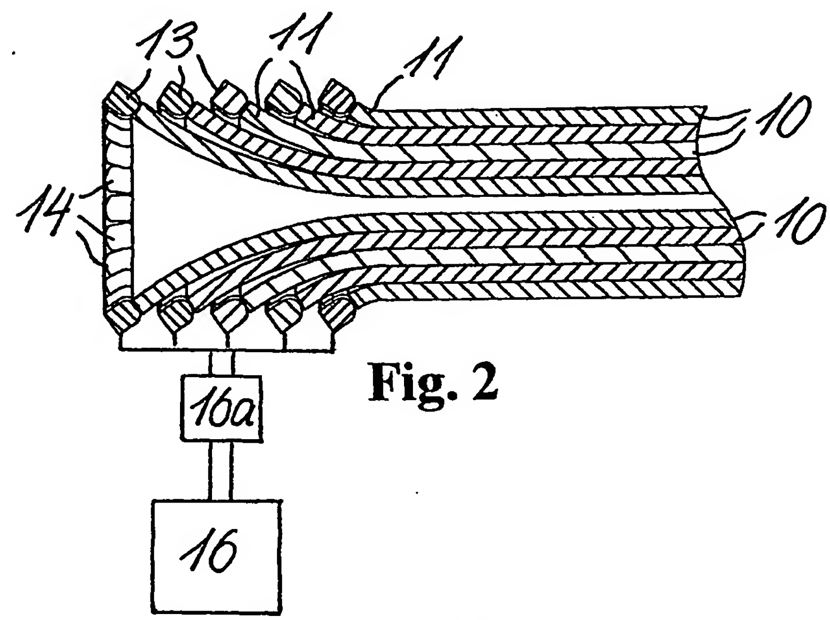


Fig. 2

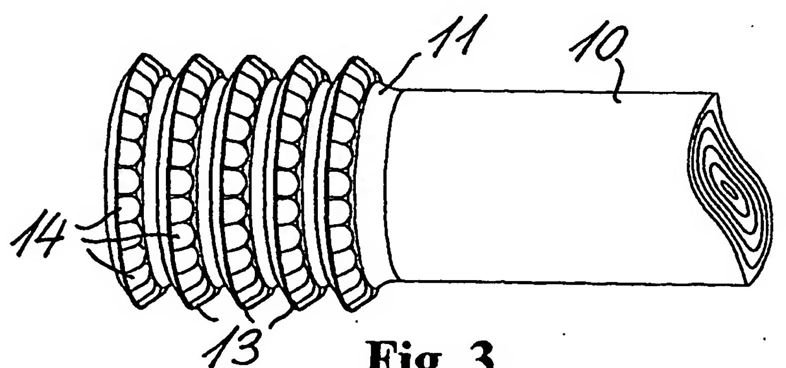


Fig. 3

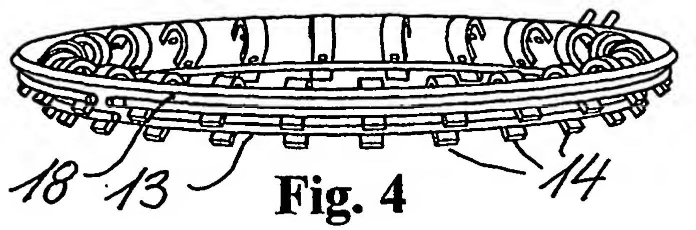


Fig. 4

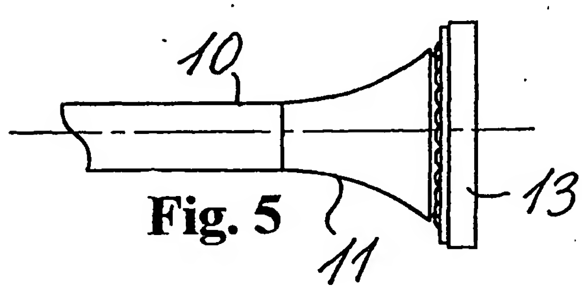


Fig. 5

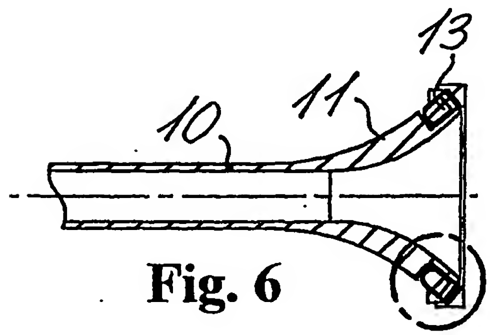


Fig. 6

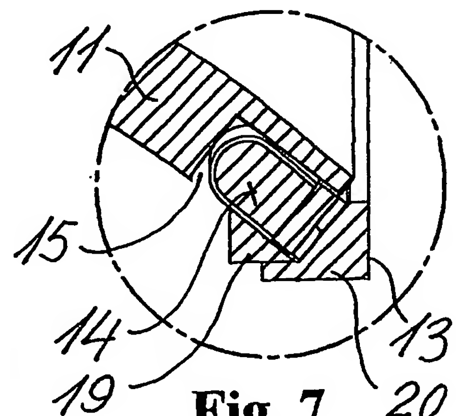


Fig. 7

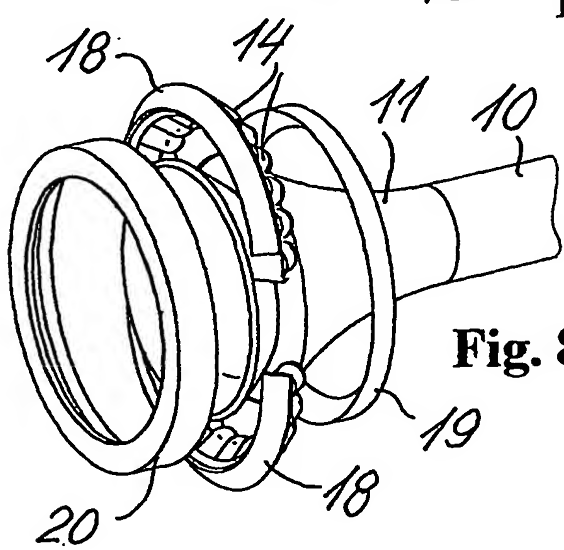


Fig. 8

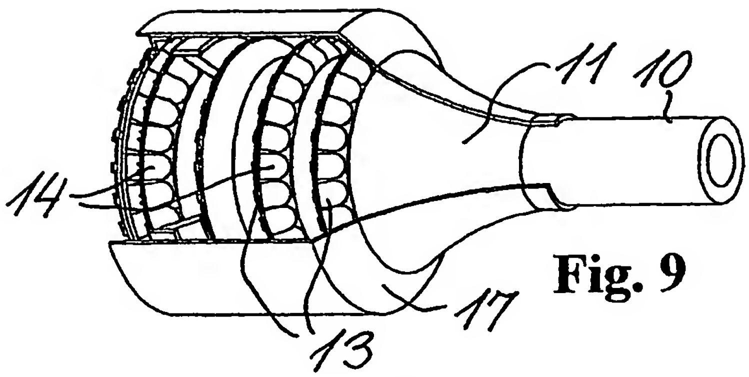


Fig. 9

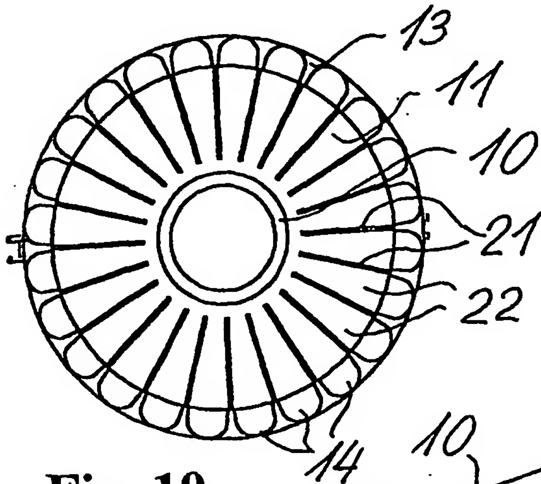


Fig. 10

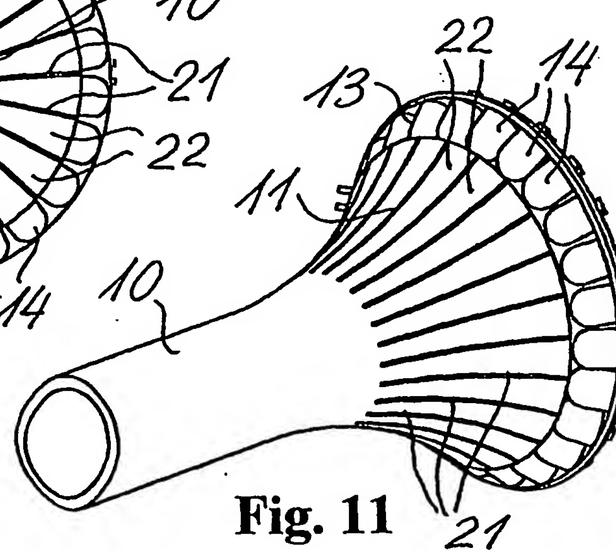


Fig. 11

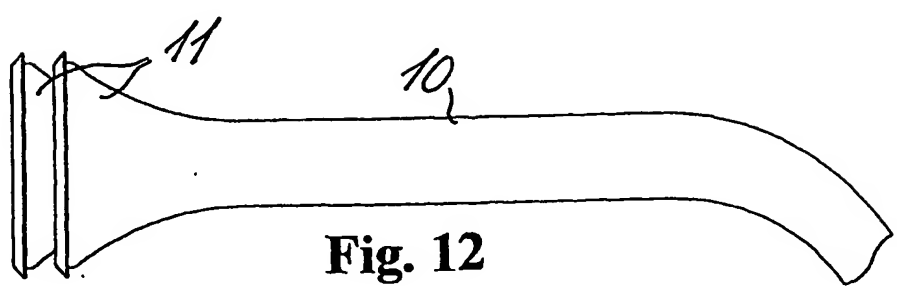


Fig. 12

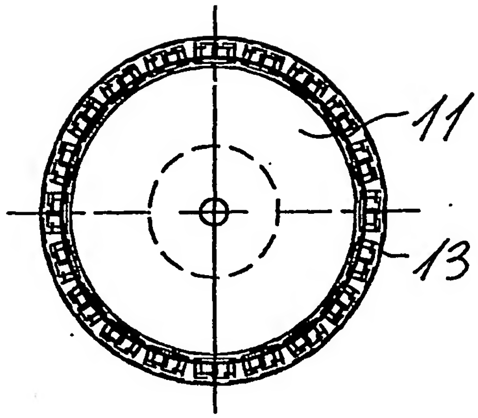


Fig. 13

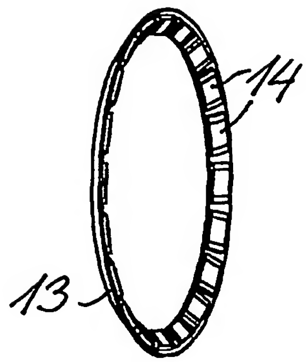


Fig. 16

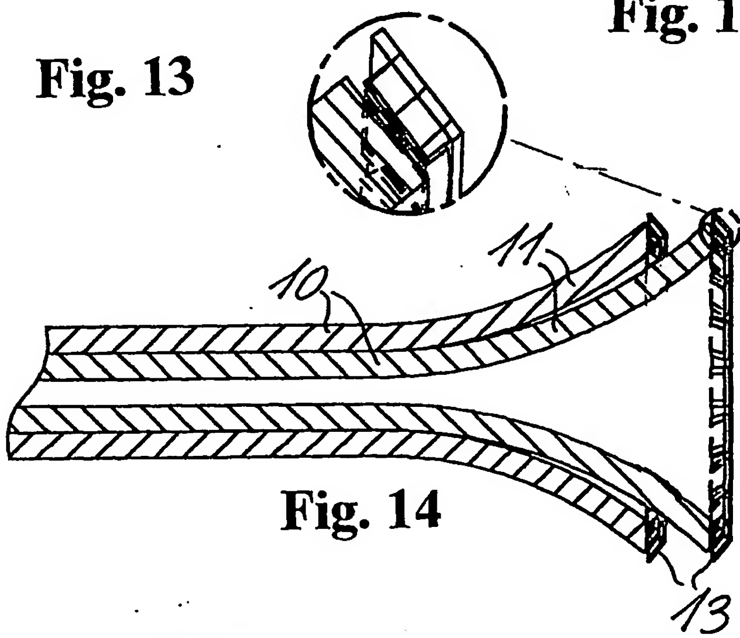


Fig. 14

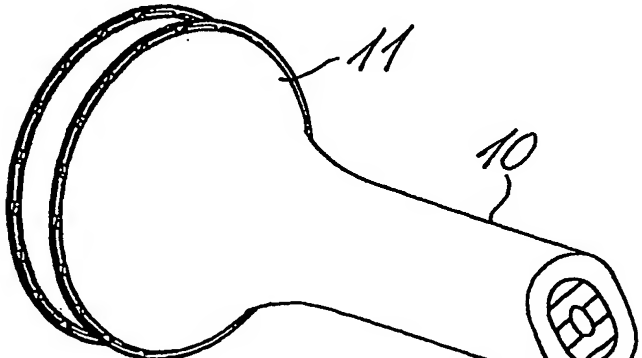


Fig. 15

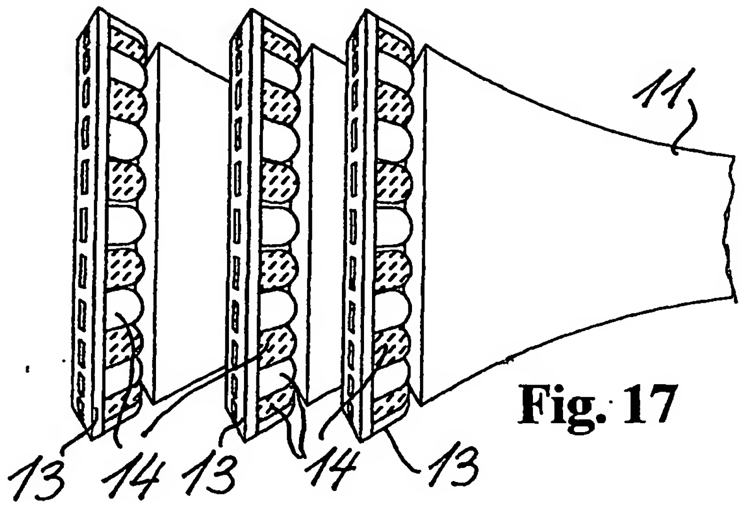


Fig. 17

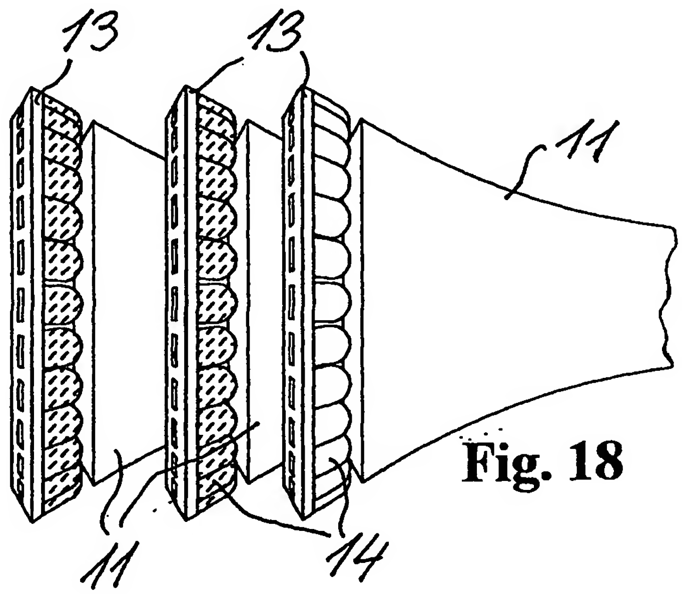


Fig. 18

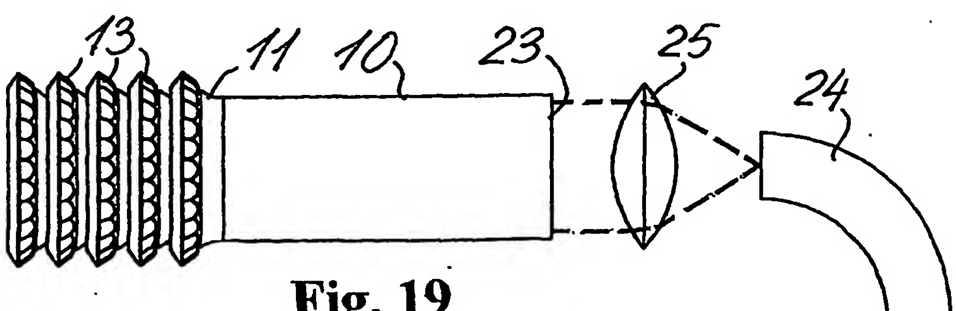


Fig. 19

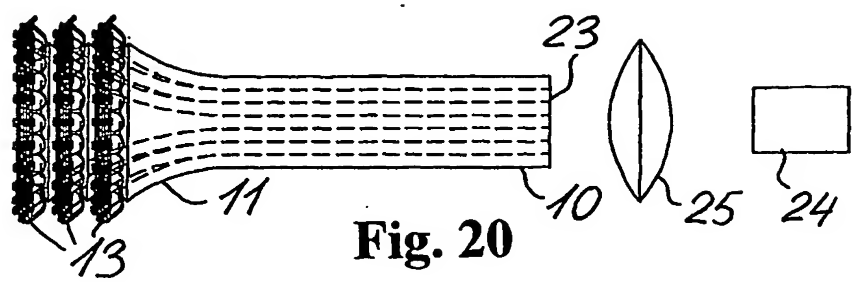


Fig. 20

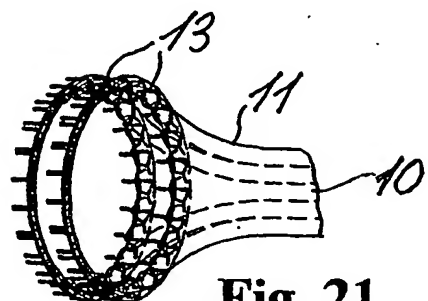


Fig. 21

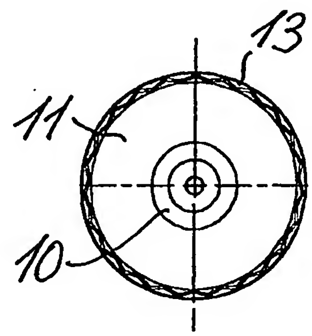


Fig. 22

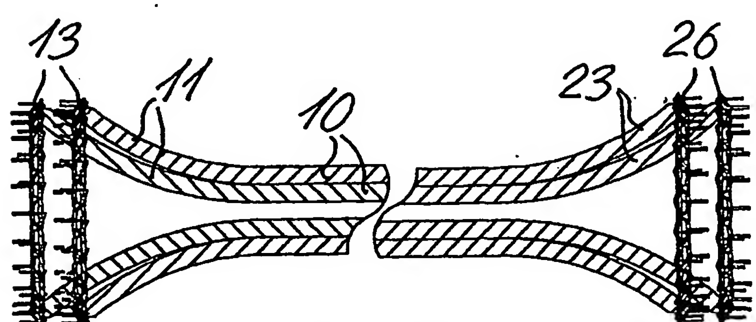


Fig. 23

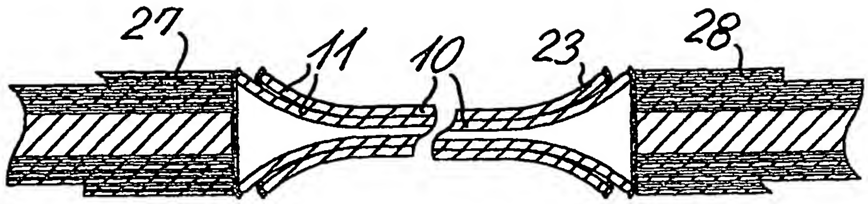


**Fig. 24**

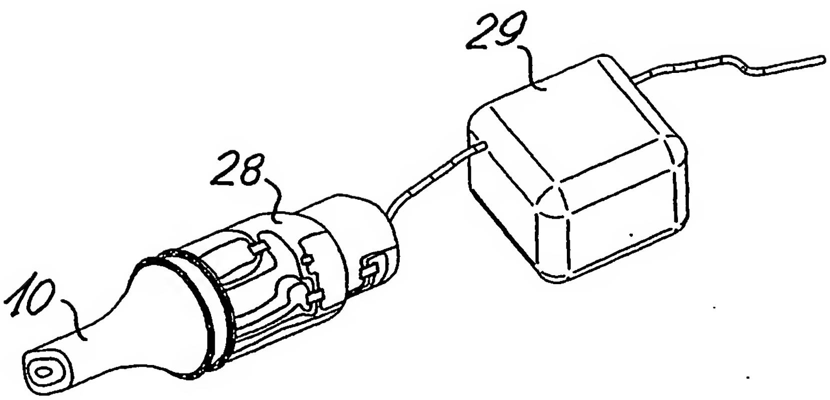


**Fig. 25**

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 01/00171

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC7: H01L 31/12, A61C 19/00, H01L 33/00
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01L, G02B, A61C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | WO 9736552 A1 (NULITE SYSTEMS INTERNATIONAL PTY.LTD), 9 October 1997 (09.10.97), see whole document<br>-- | 1-36 |
| A | WO 9916136 A1 (UNIVERSITY OF BRISTOL), 1 April 1999 (01.04.99), see whole document<br>-- | 1-36 |
| P,A | WO 0106287 A1 (COGENT LIGHT TECHNOLOGIES INC.), 25 January 2001 (25.01.01), see whole document<br>--<br>-------- | 1-36 |

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
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| 22 May 2001 | 20.07.2001 |

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**INTERNATIONAL SEARCH REPORT**
Information on patent family members

30/04/01

International application No.
PCT/DK 01/00171

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| WO 9736552 A1 | 09/10/97 | AU 2144797 A | 22/10/97 |
| | | AU PN898196 D | 00/00/00 |
| WO 9916136 A1 | 01/04/99 | AU 9178398 A | 12/04/99 |
| | | BR 9813223 A | 29/08/00 |
| | | CN 1276917 T | 13/12/00 |
| | | EP 1019970 A | 19/07/00 |
| | | GB 2329756 A | 31/03/99 |
| | | GB 9720443 D | 00/00/00 |
| | | GB 9806046 D | 00/00/00 |
| WO 0106287 A1 | 25/01/01 | NONE | |